SPQR

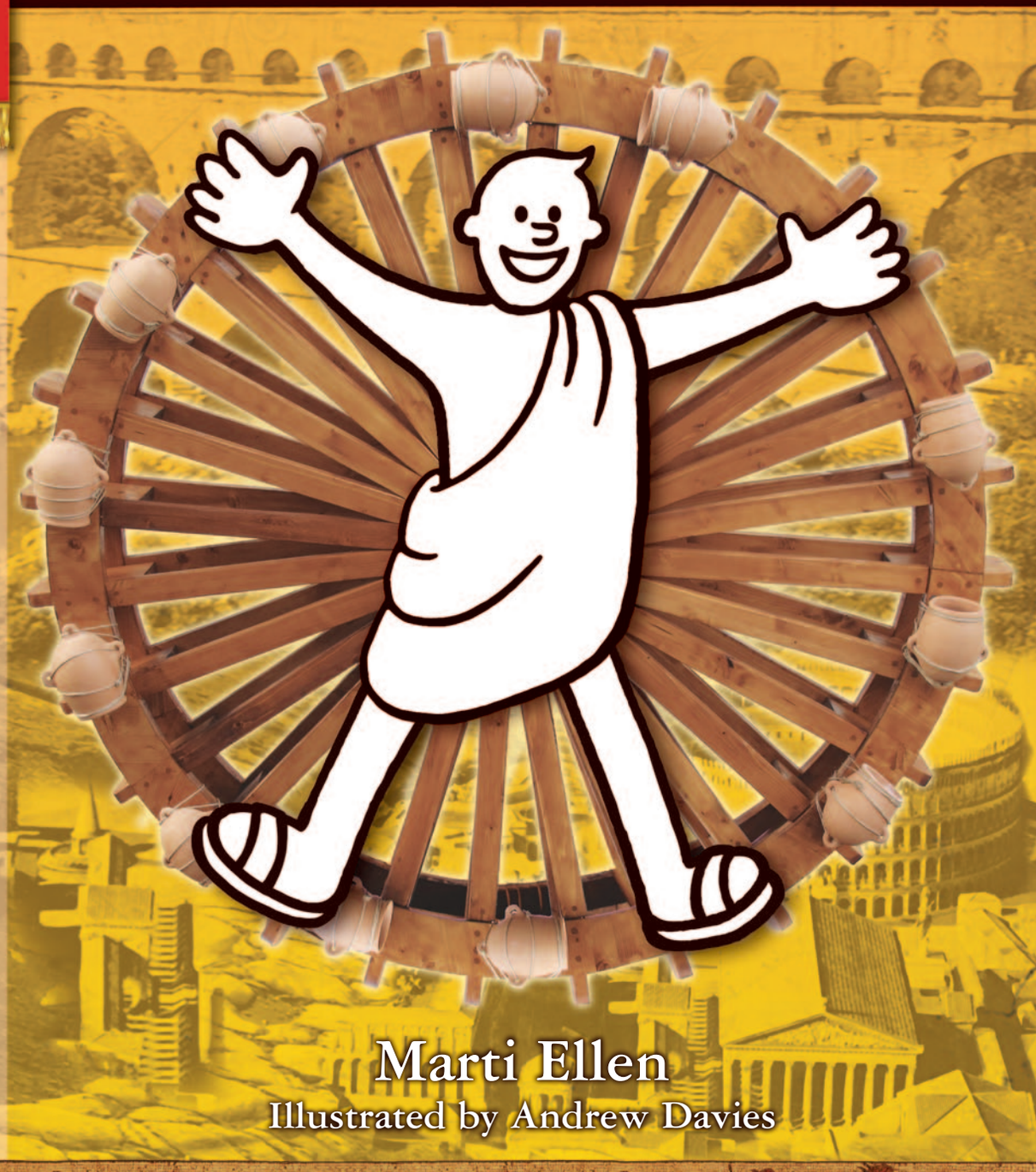
NICCOLAI SNC
TEKNOART
FIRENZE

The Official Companion to the
ROMAN MACHINES EXHIBITION

Ages 8 to Adult

PRIMARY PHYSICS

THE PRINCIPLES BEHIND ROMAN MACHINES



Marti Ellen
Illustrated by Andrew Davies

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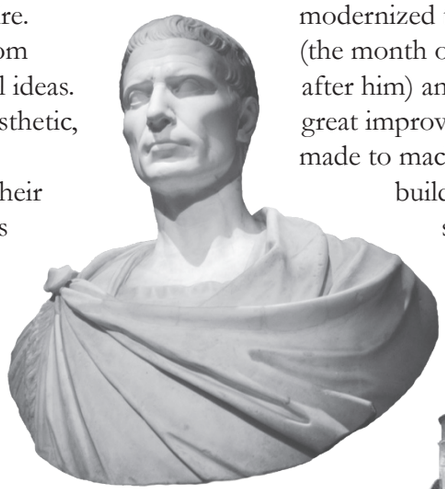
a brief history of Rome

During the period from about 753 BCE to 476 CE, the Romans built a republic and an empire that survived for many centuries and brought many inspiring changes to civilization.

Much of what the Romans developed came from the people and the cultures that they conquered, particularly the Greeks. They picked out ideas that they wanted to use in order to build and run their empire.

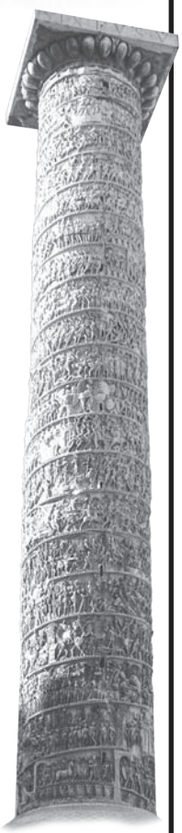
The Romans respected and learnt from scholars and incorporated many cultural ideas. Roman science was simple, practical, aesthetic, and always useful.

The Romans continually developed their cities. Many of their ideas still benefit us today, such as highways, public toilets, arenas, windows, concrete, calendars, books, calculators, notebooks, pocket timers, fast food and taxes!



JULIUS CAESAR

The Roman leader, Julius Caesar (100 – 44 BCE) was a great military general. He modernized the calendar (the month of July is named after him) and under him great improvements were made to machines for building structures such as roads, arches, bridges and weapons of war.



Julius Caesar also developed the idea of the book by dividing up scrolls onto separate pages that could be numbered. It was a military invention, brought about because of the need to refer to information quickly and easily in battle. Scrolls were cumbersome but a book allowed for one to turn to a specific page and easily locate information.

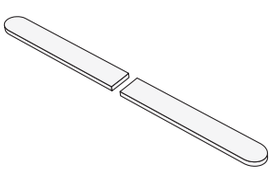
The Romans used slaves, animals and gravity power to carry out heavy work, and to build the famous structures such as arenas, aqueducts, and monuments. Many of these still stand today.

Later they also used wind and water technology for producing goods, especially as the slave populations decreased. Places in Northern Europe and England where this occured became major centres of the Industrial Revolution in the 19th Century.

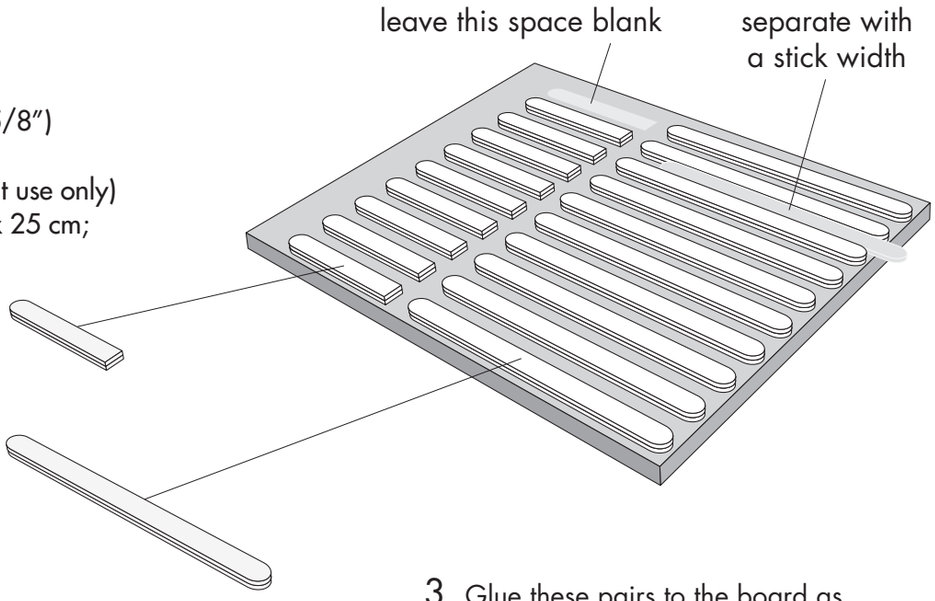
project 1 abacus

Materials

- 80 paddlepop sticks (at least). Don't use any bent ones.
- 45 marbles, diameter 15 mm (5/8″)
- craft glue
- secateurs (**important**: for adult use only)
- wooden board, at least 25 cm x 25 cm; surface must be very flat

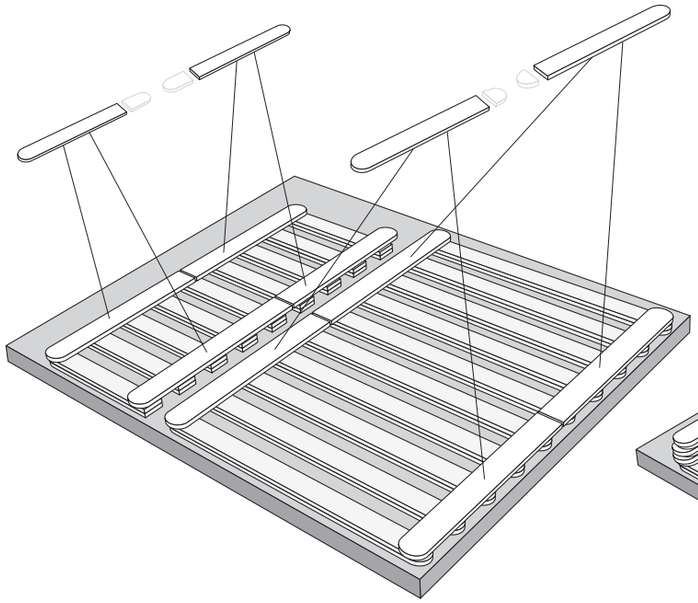


1 Cut 14 paddlepop sticks in half.

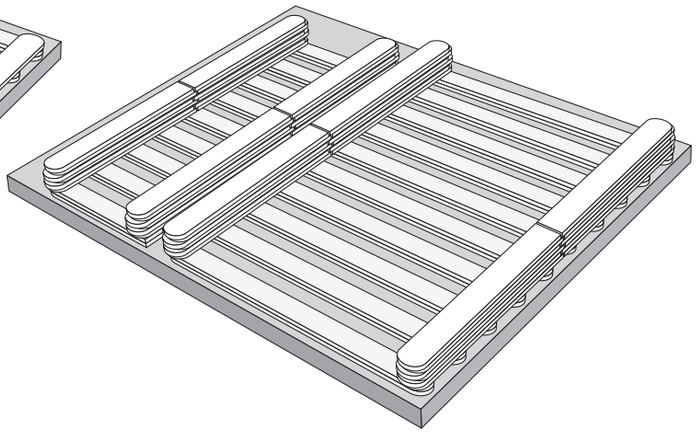


2 Join 9 half sticks to 9 half sticks and 10 full sticks to 10 full sticks.

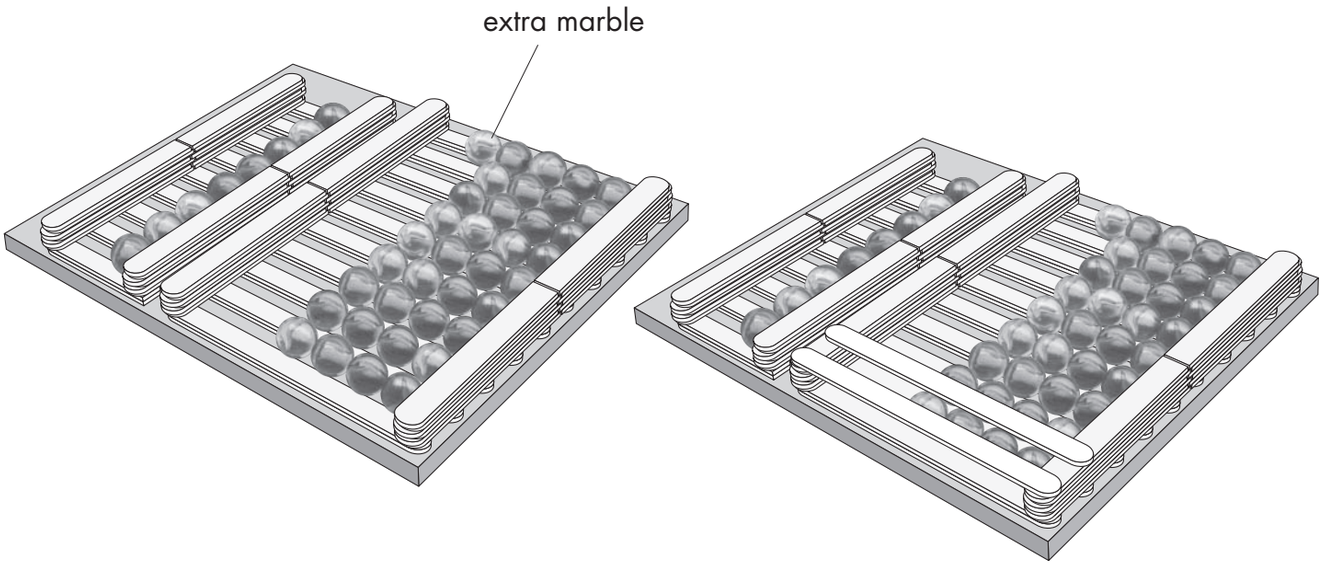
3 Glue these pairs to the board as shown. Use another stick to make sure the spacing is even and parallel. Note there is one less pair of half sticks than full sticks.



4 Have an adult cut 4 sticks with the secateurs so they are the size to fit neatly with two across the top and two across the bottom ends of the row of sticks as shown.

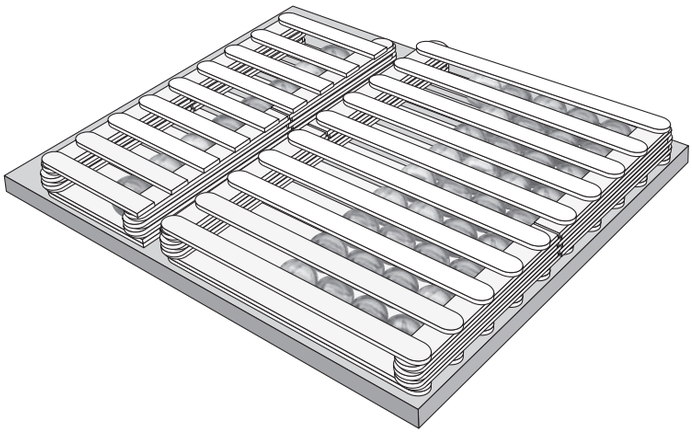


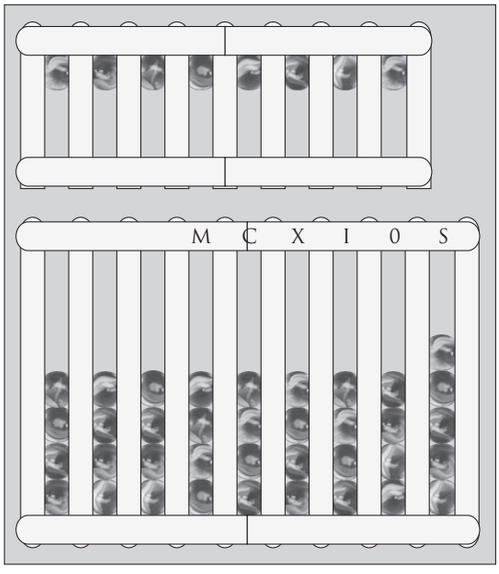
5 Add 5 more layers of sticks of the same lengths as the previous step.



6 Place one marble in each half-stick slot and 4 marbles in each full stick slot. Place an extra marble in the last slot.

7 Glue 2 full sticks above the first slot. Check whether the marbles fit snuggly, i.e. they can move easily, but not roll around. If it is too tight you may have to add more layers of sticks, or even glue a layer of cardboard to achieve the right height.





8 Add the remaining rows at the same height.

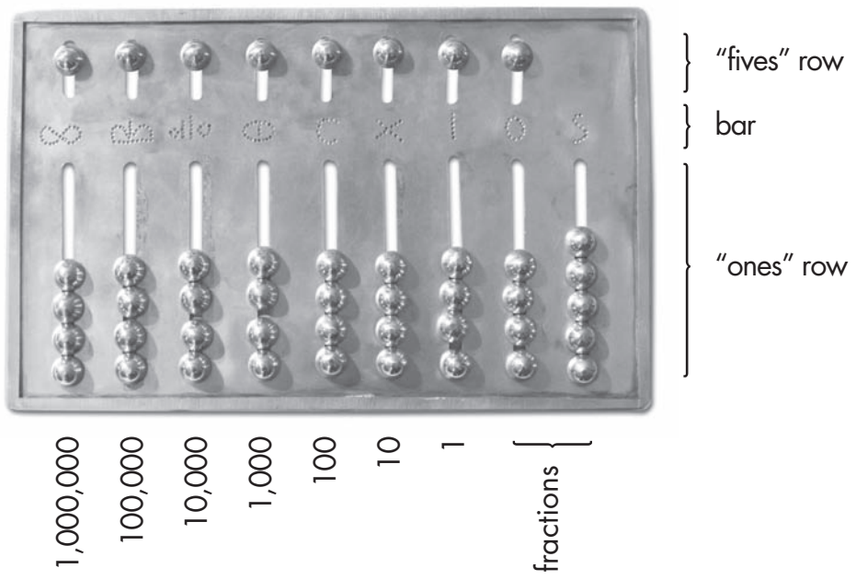
9 Inscribe numbers on each slot to indicate their value.

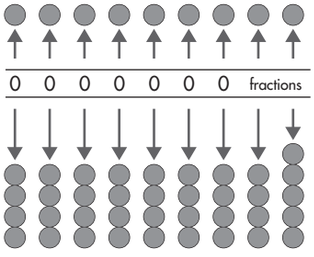
abacus

The ancient Romans used an abacus to help them with their counting and calculating of numbers. The Roman abacus was made up of columns of beads or pebbles (in this model we use marbles).

There are two rows of columns with a bar in between them. Each column signifies a different decimal value. The columns on top are short and contain one marble each signifying "five". The columns below are longer and contain four marbles each signifying "one". The one furthest to the right has five.

The two columns on the right are for calculating fractions. The last row has five beads so it can calculate twelfths (rather than tenths). The columns to the left are "I" which is the "ones" column; "X" the "tens" column; then the "hundreds" titled "C"; and then a series with symbols that signify the "thousands", "ten thousands", "hundred thousands", and "millions" columns.

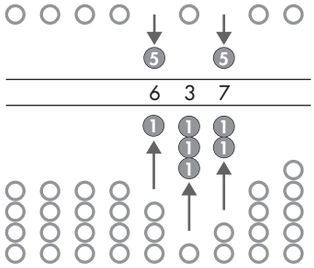




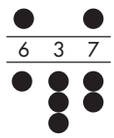
To begin using the abacus, you must first clear the abacus. This is done by pushing all the marbles in the direction away from the bar between the columns, i.e, push the marbles on top up, and the marbles in the lower columns down.

To show a number, you push the correct number of marbles towards the bar. You must always move from left to right.

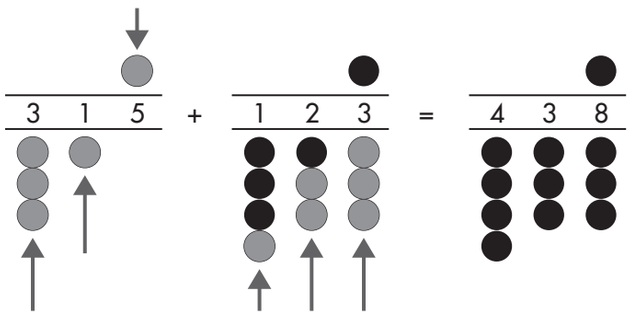
For example, to show 637, move a "five" and a "one" in the 100s column; 3 "ones" in the 10s column; and a "five" and 2 "ones" in the 1s column.



This will be shown simply as:



abacus addition

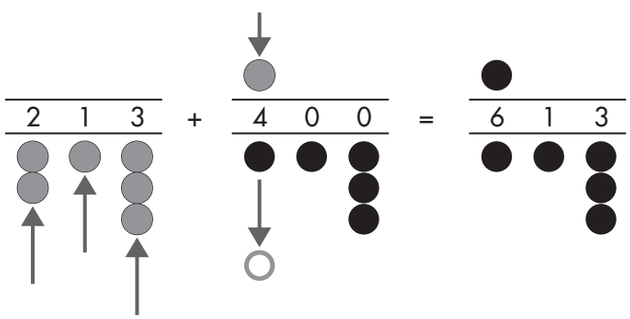


315 + 123

Set up 315: move 3 "ones" in the 100s column; a "one" in the 10s column; and a "five" in the 1s column.

To add 123: move a "one" in the 100s; 2 "ones" in the 10s; and 3 "ones" in the 1s column.

Thus 315 + 123 = 438

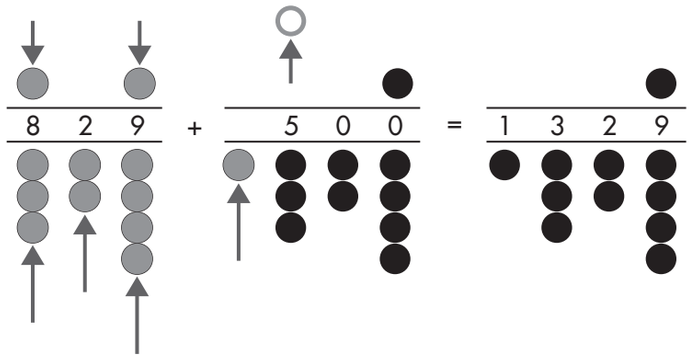


213 + 400

Set up 213: move 2 "ones" in the 100s; a "one" in the 10s; and 3 "ones" in the 1s column.

To add 400: there aren't 4 "ones" left to move so we move a "five" in the 100s, then take away a "one" in the 100s column. There are no changes needed to 10s and 1s columns.

Thus 213 + 400 = 613



829 + 500

Set up 829: move 3 "ones" and a "five" in the 100s column; 2 "ones" in the 10s; and a "five" and 4 "ones" in the 1s column.

To add 500: there is already a "five" in the 100s column, so we move it back then add a "one" in the 1,000s column.

Thus 829 + 500 = 1,329

Try these sums on your abacus:

231 + 340 =

782 + 131 =

1,317 + 422 =

22,456 + 34,403 =

Roman arch

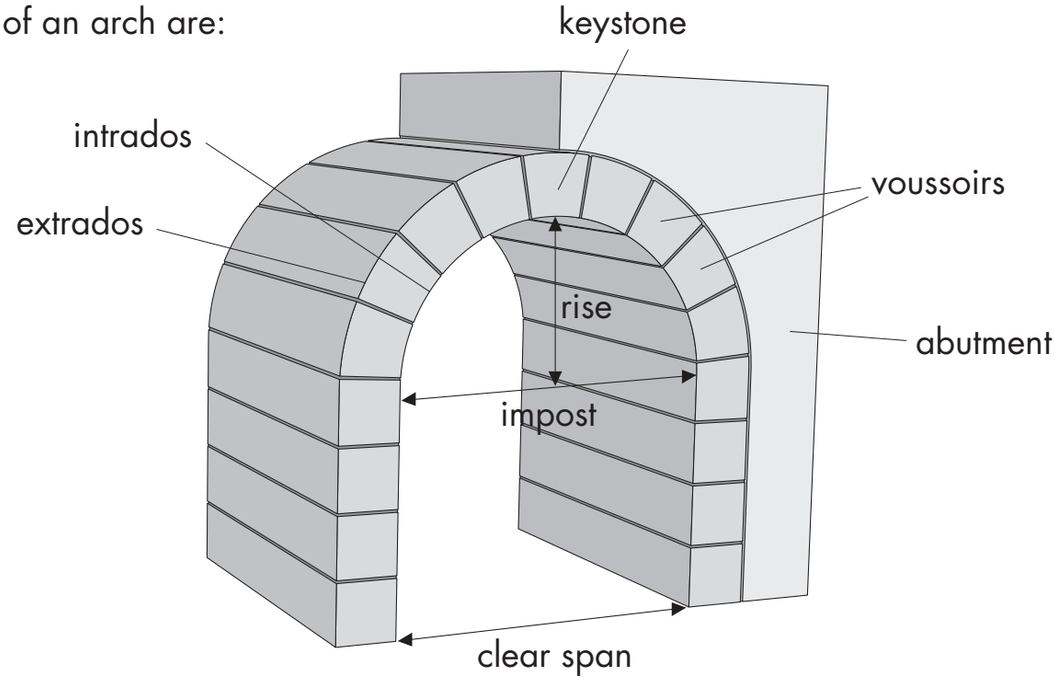
I'm sitting atop one
of the greatest inventions in history –
THE ARCH.

My fellow countrymen used arches in the design of our buildings and developed magnificent structures based on the humble arch.

When made of lightweight material, like our newly invented concrete, multi-storey buildings became possible.

Our engineers were inspired and designed monuments, bridges, aqueducts and many other things using arches – practical things which will stand the test of time. The importance of the arch is that it increases space and volume, while reducing mass and weight.

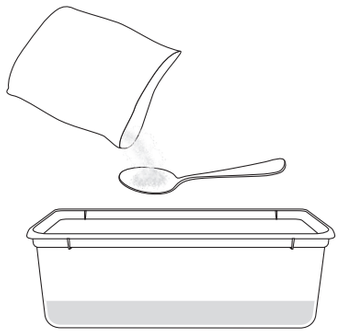
The parts of an arch are:



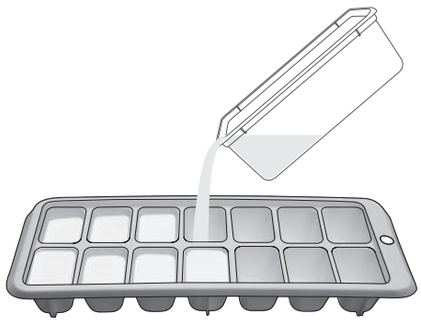
project 4 Roman arch

Materials

- ice cube tray
- plaster
- water
- plastic container to mix
- paddlepop stick (to stir, and scrape off plaster powder level)
- sand paper (rough and smoother)
- masonite placemat
- piece of cardboard
- pen
- 15 cm (6″) ruler



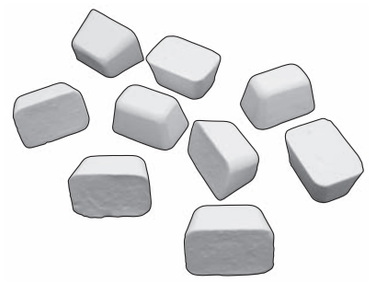
1 Mix plaster according to instructions. Measure carefully so the plaster sets properly. Scrape the powder flat on the spoon to get accurate quantities.



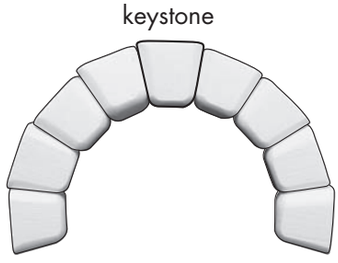
2 Quickly but carefully pour the liquid plaster into an ice cube tray. Fill the cubes to the top, and all the same size. Make about 12 blocks.

3 Allow to set.

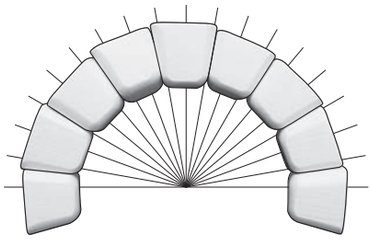
4 When hard, remove from tray.



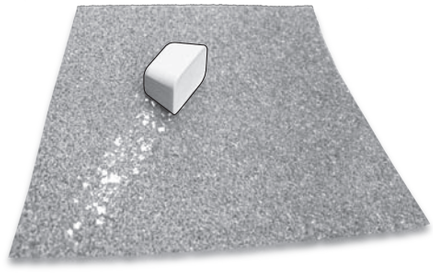
5 Allow to dry overnight, or longer, depending on weather conditions.



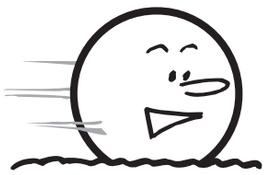
6 Put the largest block you have as the keystone, at the top. Line up several blocks, side by side to make an arch shape.



7 Depending on the shape of the blocks, you may need 7, 9 or 11 blocks to make an arch of at least 180°.



8 Rough up the 4 sides of each block with the smooth sandpaper. This will help them hold onto each other. Be sure to only sand in one direction, and don't change the shape of the blocks.



friction

Things you need

Different surfaces:

- paper
- sandpaper, different grades 6 cm x 8 cm (3″ x 5″) each
- waxed paper
- recycled paper
- cardboard
- chalk
- crayon
- soft pencils

Words to use

rough smooth
rub friction
heat small
disappears

Extension

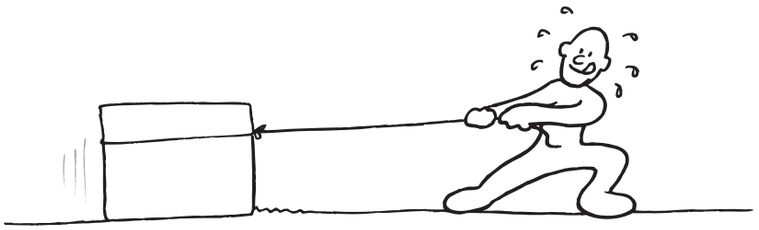
See how long it takes to wear away these:

1 cm (1/2″) of chalk on sandpaper;

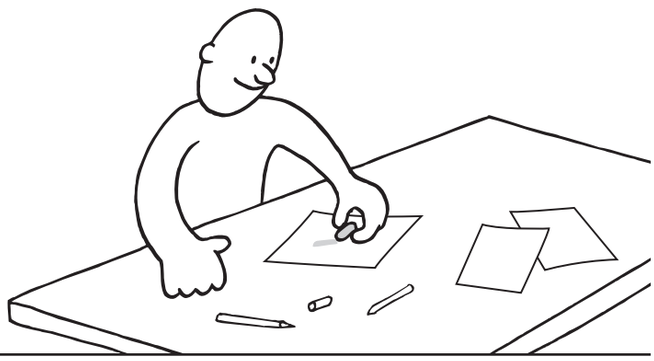
1 cm (1/2″) of crayon on sandpaper.

Note: Use a longer piece so you can hold it safely. Measure 1 cm from the end and mark that spot.

Rubbing



Draw on different types of surfaces



When you rub on sandpaper, what happens to the crayon, chalk or pencil? _____

Is the sandpaper still as rough after you have used it? _____

What happened? _____

Friction is the rubbing force. The rougher the surface, the **more** friction there is.

How did you use friction to form your block? _____

In your Roman arch, identify all the places where there is friction. _____

How is friction helpful? _____

How is it harmful? _____

What changes could you make in your Roman arch to take advantage of friction? _____

_____

The Romans used arches such as this in many situations, including bridges, windows and aqueducts. The same method is still used today.

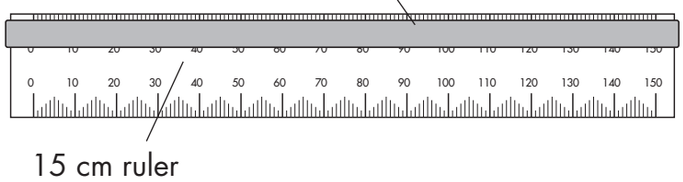
gravity 3

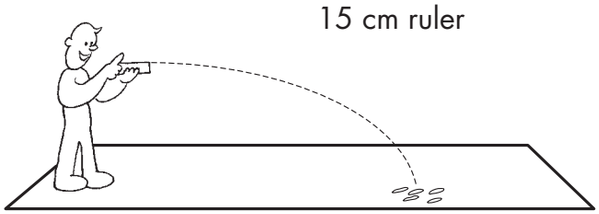
Things you need
- rubber bands, size 64
- 15 cm (6″) ruler

Words to use
angle
distance
fall
gravity
force
mass
launch
elevation

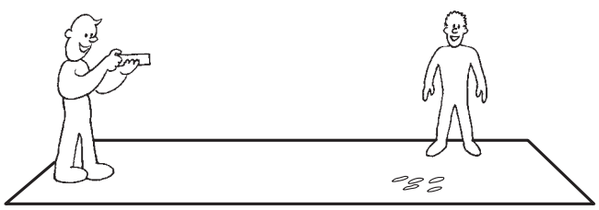
How long will it take to fall?

Make a rubber band launcher.

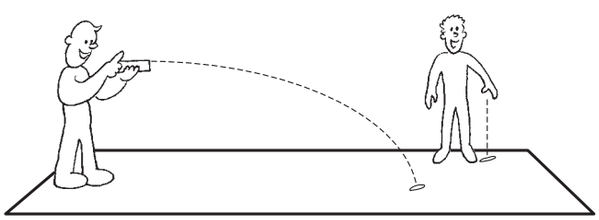




Hold the launcher level and practice shooting rubber bands until you can shoot consistently.



Have someone stand at that distance, but well to the side so they don't get shot with a rubber band.



At the same time, the two people shoot the rubber band and drop the rubber band.

What happens? _____

_____

How can you explain this? _____

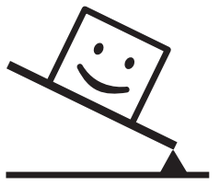
_____

Your onager has similarities and differences to your rubber band launcher. List three similarities and differences.

_____

_____

_____



levers 1

Things you need

- tongs
- see saw
- garlic press
- nut-cracker
- scissors
- stapler
- scales

Words to use

lever
fulcrum
load
effort
class
type

Extension

Make a list of other levers you have seen, what they are used for, and what is their class of lever.

_____

_____

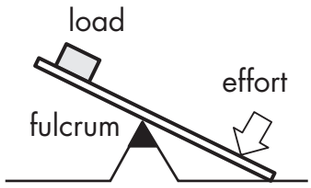
_____

_____

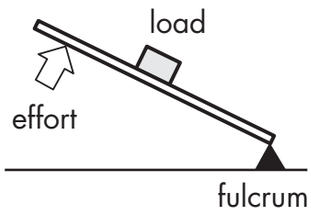
_____

_____

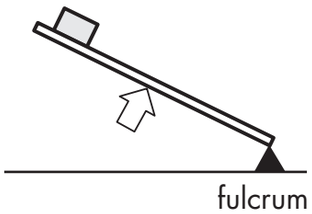
There are 3 basic kinds of levers



class 1 lever

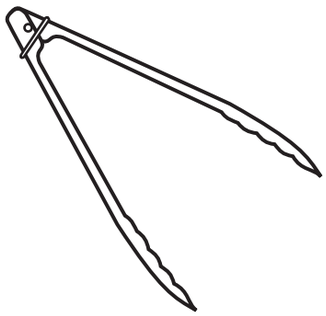


class 2 lever



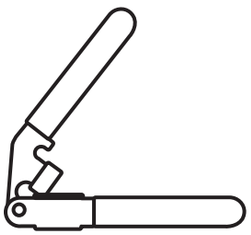
class 3 lever

Which class of lever are each of these things?



tongs

Class ____

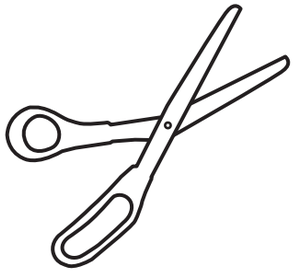


garlic press

Class ____

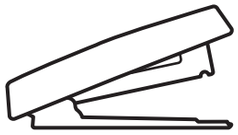
scales

Class ____



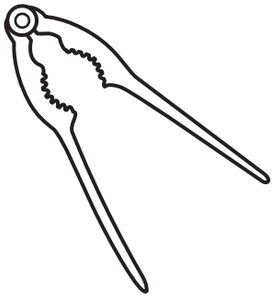
scissors

Class ____



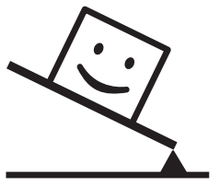
stapler

Class ____



nut-cracker

Class ____



levers 2

Things you need

- scissors
- scrap paper
- nut cracker
- nuts in shell (e.g. walnuts)
- tongs
- marbles
- 2 plastic containers

Words to use

fulcrum
load
effort

Extension

Have a party.

Use different types of levers for preparing and serving the food. List the utensils you use below.

_____

_____

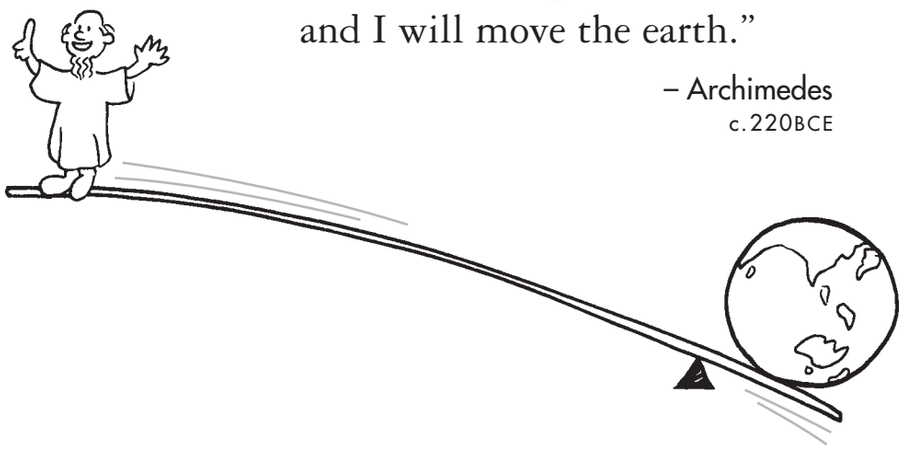
_____

_____

_____

"Give me a firm spot to stand on and I will move the earth."

– Archimedes
c.220BCE



Set up three stations with the three types of levers. Try each.

Class 1
Cut out a shape from a piece of paper using scissors.

Class 2
Crack open some nuts.

Class 3
Use tongs to transfer marbles from one container to another.

Which type of lever is your onager? _____